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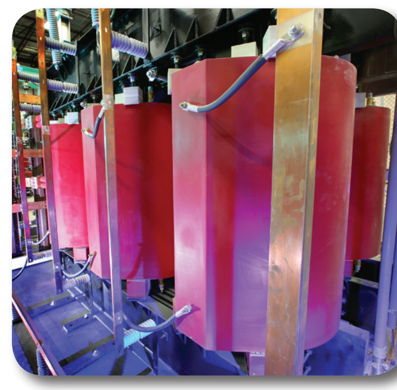
Photo credits: *LeRoy N. Sanchez, IRM-RMMSO*

NHMFL Staff Scientist Dwight Rickel checks the 100 Tesla Multi-shot Magnet.

National High Magnetic Field Laboratory

One-of-a-kind magnets and experts in pulsed magnet science make the NHMFL Pulsed Field Facility a unique user laboratory.



Transformers, part of the 600 megajoule power plant.

The opportunity to explore new scientific frontiers awaits users of the National High Magnetic Field Laboratory's (NHMFL) Pulsed Field Facility at Los Alamos National Laboratory. With the recent commissioning of its 100 Tesla Multi-shot Magnet, the world's most powerful pulsed, nondestructive magnet, the facility is the only place in the world where researchers can design experiments using the highest magnetic fields ever non-destructively produced on a repetitive basis.

The magnet is just one available to participants of the only pulsed field user program in the United States. The NHMFL's 60 Telsa Controlled Waveform Magnet allows for a customized magnetic field waveform that can be designed to suit specific experiments. The fully operational single turn system, which provides users with an ultra-high field capability extending to 300 tesla, uses a "fast" capacitor bank capable of producing 4 MA current pulse into a low inductance (7nH) load. The result is a 6 microsecond duration magnetic field pulse, with forces so far beyond the material strengths that the simplistic coil is destroyed with each pulse. The system is carefully designed, however, to cause no damage to the sample and the cryostat, allowing for a comprehensive study of the sample.

At the heart of pulsed field activities at the NHMFL-PFL is a fully multiplexed and computer controlled six position 1.6 mega-joule capacitor bank system. Some 4,000 shots per year are fired for the user's program, which accommodates approximately 120 individual user groups.

The Pulsed Field Facility not only allows access to a wide variety of experimental capabilities in pulsed magnetic fields, but also allows researchers assistance from some of the world's leading experts in pulsed magnet science. All user support scientists are active researchers and collaborate with multiple users per year.

The Pulsed Field Facility at Los Alamos is one of three campuses of the National High Magnetic Field Laboratory; the other two being located in Florida. The NHMFL is sponsored primarily by the National Science Foundation, Division of Materials Research, with additional support from the State of Florida and the U.S. Department of Energy.

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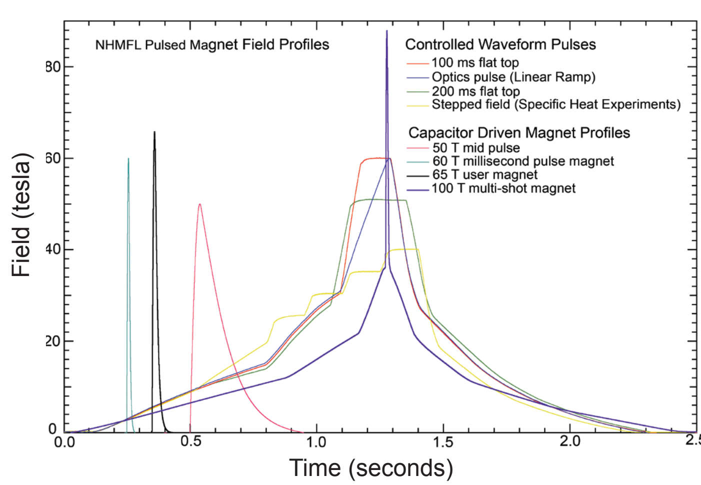
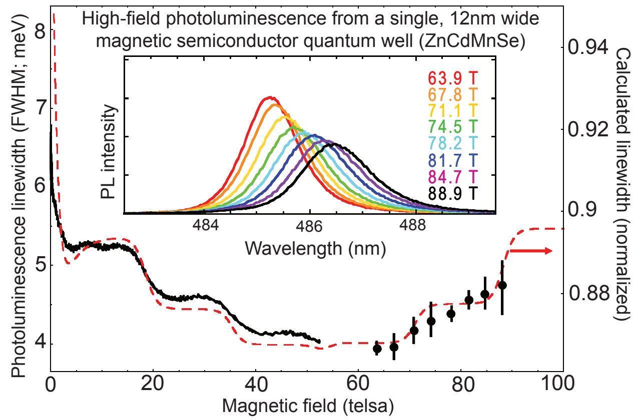


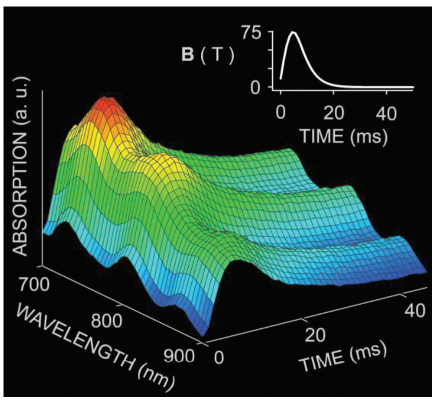
National High Magnetic Field Laboratory

Recent research and development highlights

Tuning alloy disorder in diluted magnetic semiconductors in high fields to 89 tesla



In the first experiments taking advantage of the 100 Tesla Multi-Shot Magnet's unique capabilities, researchers from the NHMFL and Pennsylvania State University studied the field-tunable alloy disorder potential in a single diluted magnetic semiconductor (DMS) quantum well (shown in figure)[1]. A critical and as-yet-unverified aspect of current models is the expectation[1] that alloy disorder in many DMS materials should increase as antiferromagnetically-bound clusters of Mn spins achieve full alignment at very high magnetic fields—typically of order 50-100 tesla. The researchers measured the disorder potential from a single $Zn_{.70}Cd_{.22}Mn_{.08}Se$ quantum well to 88.9 tesla. The 100 tesla magnet allows non-destructive access to this ultrahigh field regime and—importantly— sufficiently long pulse duration to permit collection of high-resolution photoluminescence linewidth data. They observed that the linewidth markedly increased above 70 tesla, in qualitative agreement with a simple "local-bandgap" model of compositional alloy disorder, thus validating current models of field-tunable alloy disorder in DMS materials.



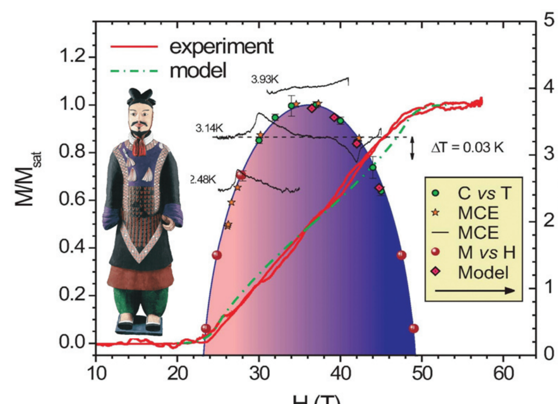
Carbon nanotubes in high magnetic field

Carbon nanotubes (CNTs) are potentially the perfect one-dimensional conductors. Their magnetic field properties are intriguing and provide a useful physical insight into systems with restricted dimensionality. However, it is difficult to handle CNTs the way in which ordinary condensed matter samples are due to their nanoscopic dimensions. Users from Rice University in the research group of Professor Jun Kono and extensive collaborators from around the globe used magneto-absorption spectroscopy in the highest milli-second duration pulsed magnetic fields (to 75 tesla) to study the diamagnetic alignment and chirality dependent photo-absorption of aqueous suspended CNTs[2].

At left, magneto-absoption spectroscopy of carbon nanotubes in an aqueous solution. Data were taken up to 75 tesla at the NHMFL-PFL.

Dimensional reduction at a quantum critical point

NHMFL scientists studying magnetic waves in a 2500-year-old pigment known as Han purple discovered that when they exposed newly grown crystals of the ancient pigment to very high magnetic fields (above 23 tesla) at very low temperatures (between 1 and 3 degrees Kelvin), it entered a rarely observed state of matter, known as the Bose Einstein condensate (BEC). At the threshold of that matter state—called the quantum critical point—the waves actually lost a dimension going from a three-dimensional to a two-dimensional pattern. The discovery is yet another step toward understanding the quantum mechanics of the universe. The researchers believe the lost dimension phenomenon is caused by the strange nature of atomic behavior in quantum states[3].



At right, high field results indicate that the Bose–Einstein condensate of spin triplets in the three-dimensional Mott insulator $BaCuSi_2O_6$ provides an experimentally verifiable example of dimensional reduction at a quantum critical point.[4]

References

[1] S. A. Crooker and N. Samarth, *Appl. Phys. Lett.* **90**, 102109 (2007).
[2] S. Zaric et al. *Phys. Rev. Lett.* **96**, 016406 (2006).
[3] S. E. Sebastian et al. *Nature,* **441**, 617 (2006).
[4] M. Jaime et al. *Phys. Rev. Lett.* **93**, 087203 (2004).

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